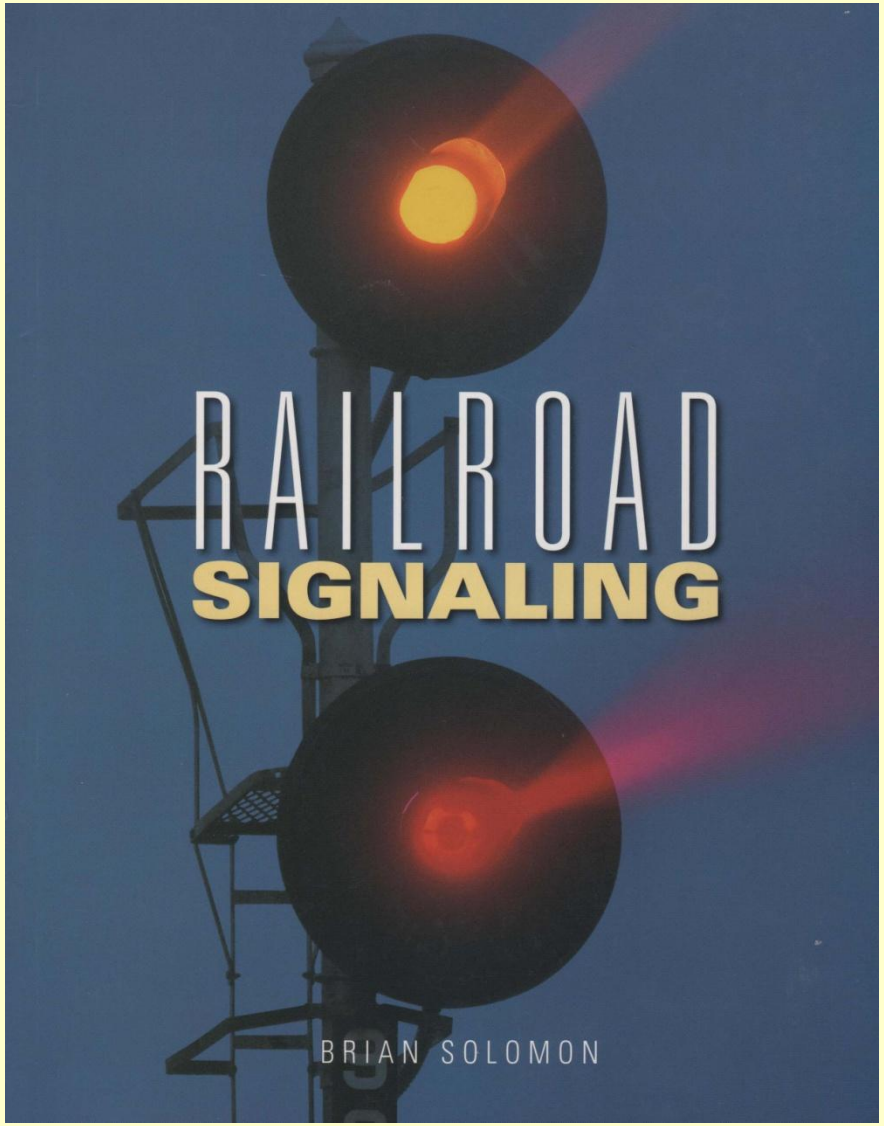
Signals



Based on information from a book by Brian Soloman

Signals

In the early days of railroading there wasn't enough traffic to need signals and everything ran on a timetable

Rocky Mountain Central

Southbound Trains				TIME TABLE No. 27 August 12, 1956			Northbound Trains			
Second Class		First Class					First Class		Second Class	
No. 31 Salida Turn	No. 21 Leadville Express	No. 5 Limited	No. 3 Daylight				No. 4 Zepher	No. 6 Prospector	No. 20 Coal	No. 32 Salida Turn
9:00	**10:10**	**14:00**		Dep	**Denver**	Arr	20:30		14:53	16:33
10:18	11:28	15:18		Arr	**Pueblo**	Dep	19:12		13:35	15:15
		15:23		Dep		Arr	18:42			
11:23	12:33	16:28		Arr	**Salida**	Dep	17:37		**12:30**	**14:10**
		16:43		Dep		Arr	17:07			
	13:58	18:08		Arr	**Leadville**	Dep	15:42			
		18:23		Dep		Arr	15:12			
		19:07		Arr	**Glenwood Springs**	Dep	14:28			
		19:22	**8:00**	Dep		Arr	13:58	17:28	21:40	
		20:47	9:25	Arr	**Orestod**	Dep	12:33	16:13	20:15	
		21:02	9:55	Dep		Arr	12:13	15:43		
		22:31	11:24	Arr	**Kremmling**	Dep	10:44	14:14	18:46	
		22:46	11:54	Dep		Arr	10:14	13:44		
		23:58	13:06	Arr	**Sulphur Springs**	Dep	9:02	12:32	17:34	
		0:13	13:36	Dep		Arr	8:32	12:02		
		0:45	14:08	Arr	**Denver**	Dep	**8:00**	**11:30**	16:30	

<---------Read Down

Read Up--------->

But as frequency, weight and speed all increased, something was needed to lessen the potential for collisions

Signals

The first known signal was in Britain where the Liverpool and Manchester positioned railroad policemen along the line. There job was not only to keep the public off the tracks but to indicate to passing trains the condition of the track ahead.

An outstretched arm indicate the line was clear

While arms at the side indicated a problem

Signals

The first use of fixed signals in the U.S. was by a short 17-mile long line called the Newcastle and Frenchtown Railroad

They erected a network of masts approximately 3 miles apart and using a hoist system raised black or white flags to indicate a trains progression

The flags proved ineffective and they changed to balls

A White ball meant the train was on time
A Black ball meant the train had left late
When the train departed the ball was lowered to half mast

Signals

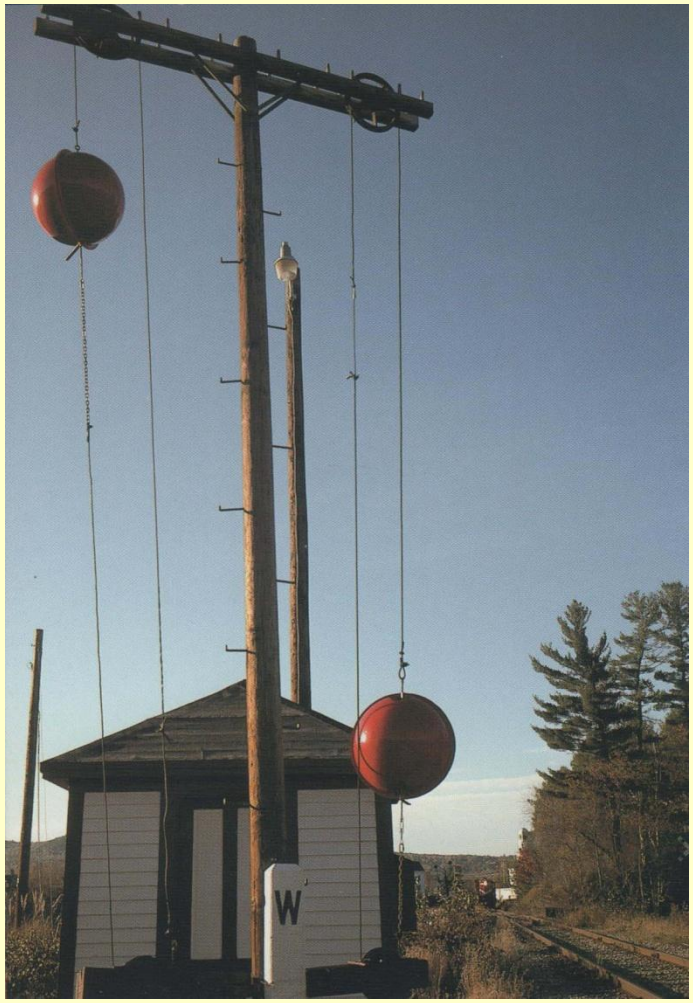
This gave way to the ball system seen here

The ball is raised to the top to indicate the line is clear and lowered to indicate it is not so the rule was…

If a Signal Ball is clearly visible, the line is clear, if not then the approaching train must stop

Pop Quiz:
The use of ball signals led way to what common term?

"Highball" which means proceed



Signals

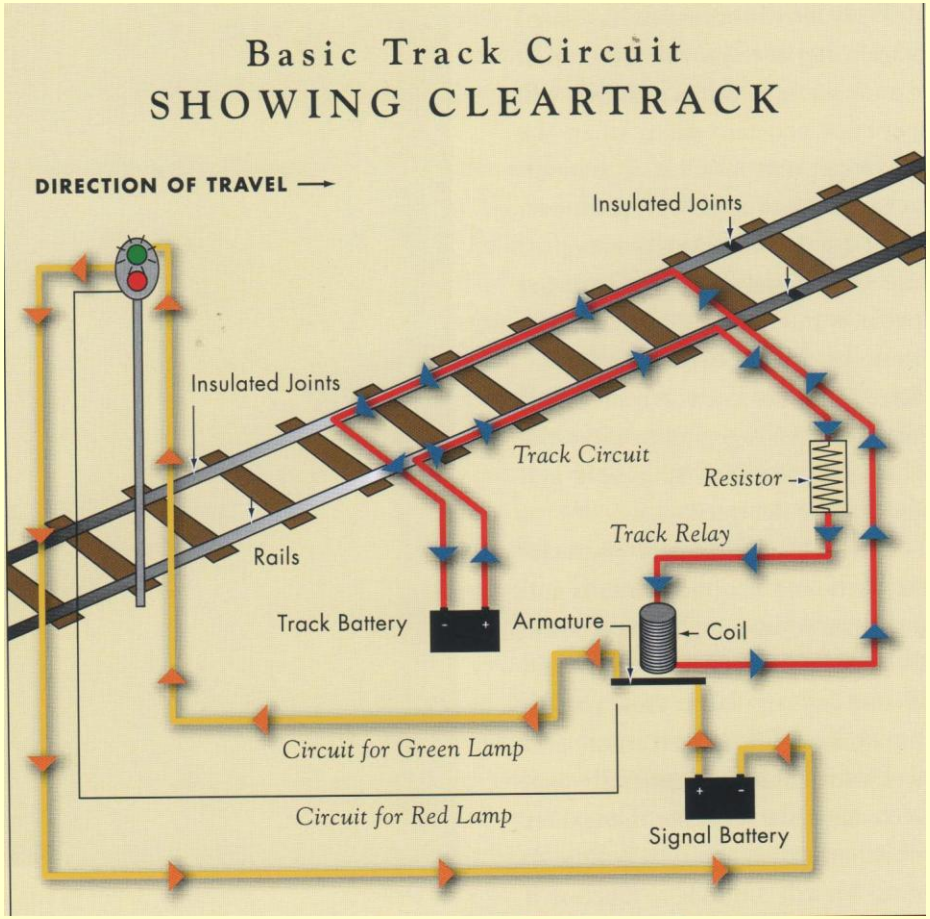
A "track circuit" that provides track occupancy indication was finally proven reliable in 1870 by William Robinson at the New York city fair where he convinced the Philadelphia and Erie to further his experiments…..and automatic block control was born

While originally an "open-circuit" system it was later changed to a "closed-circuit" for failsafe reasons so any break in the rail or any wheelset shunting the circuit would cause a "stop" indication

The track circuit is a fundamental part of Automatic Block Signals (ABS), Centralized Traffic Control (CTC) and many other forms of train control used today.

Signals

Basically the track is divided into electrically insolated sections using insulated rail joints (sounds familiar). Current, usually from a low-voltage battery, is passed along one rail then through a resistor and a track relay and returning along the other rail.

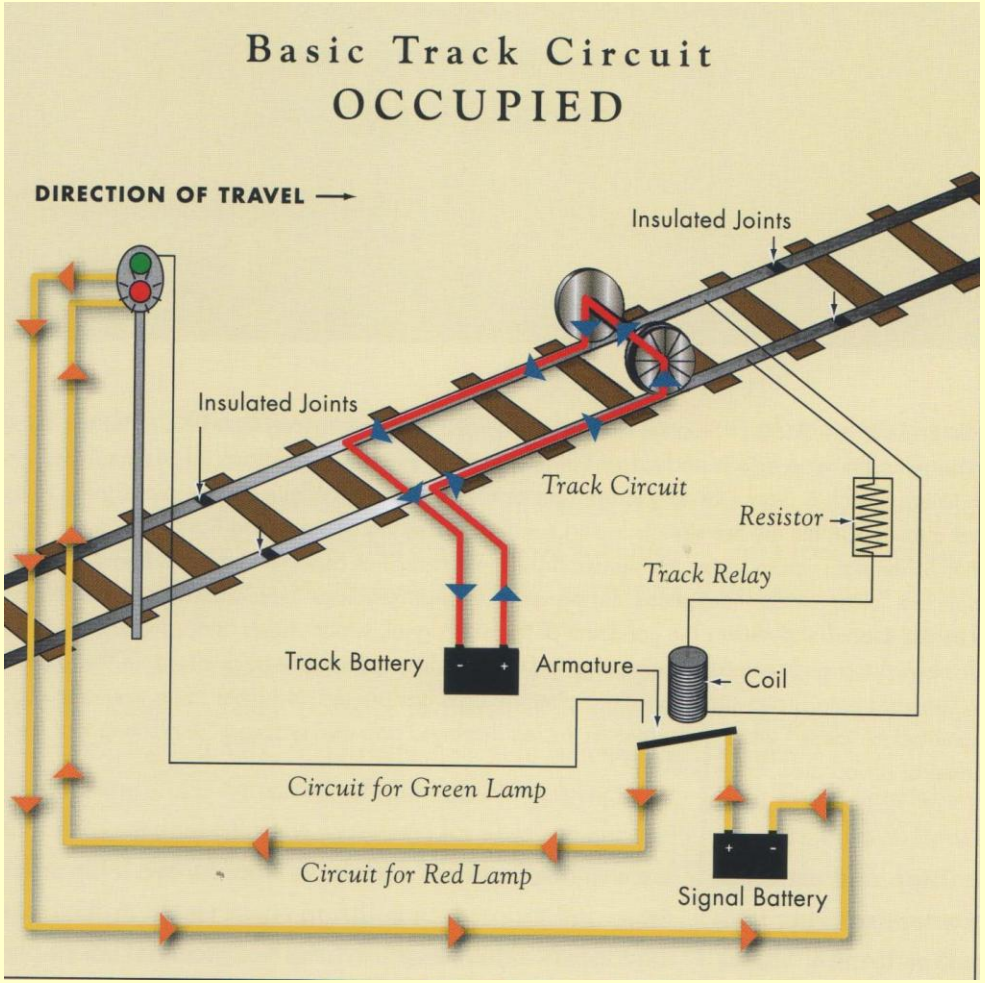


When the track is clear the relay is energized causing its armature to rise and complete a secondary circuit that displays a "clear".

This "must be energized to display a clear" results in a failsafe mode if the system looses power.

Signals

When the all metal wheels enter the circuit it has less resistance than the relay so it "shunts" the circuit and de-energized the relay causing its armature to drop and de-energize the secondary relay while simultaneously connecting the "stop" aspect.



There's a bunch of things to consider such as weather, chemicals, etc. that might affect the conductivity of the circuit.

In some cases there have been rules like "running singly without cars will not be performed on ABS trackage without dispatchers authorization"

Signals

This invention lead to automatic block control

Automatic block control was primarily designed for following traffic to prevent rear end collisions

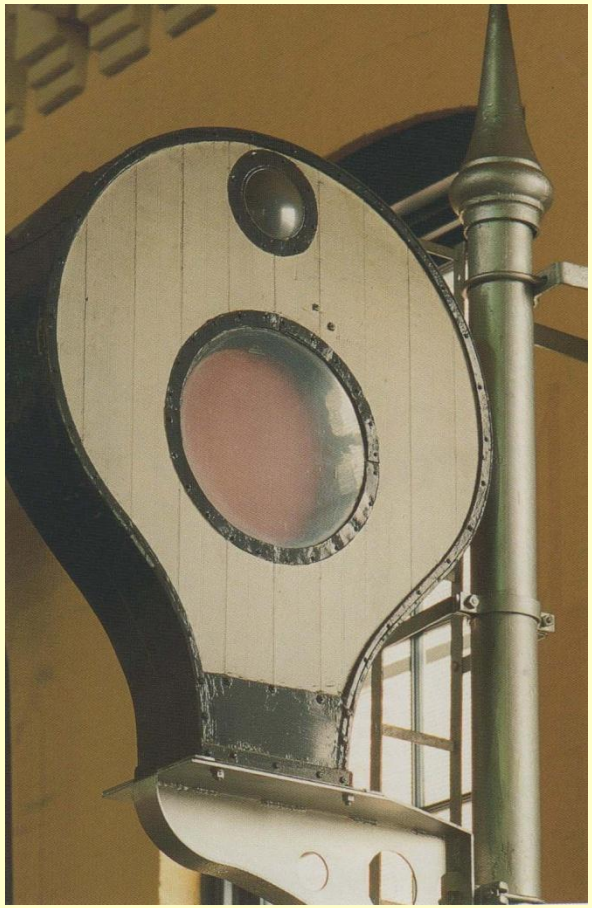
Pop Quiz:
Can you name a famous rear end collision that could have been prevented with automatic block control?

The Illinois Central on April 30, 1900 where the engineer of the express passenger train, the "Cannonball" was killed

Bonus question, what was his name? Casey Jones

Signals

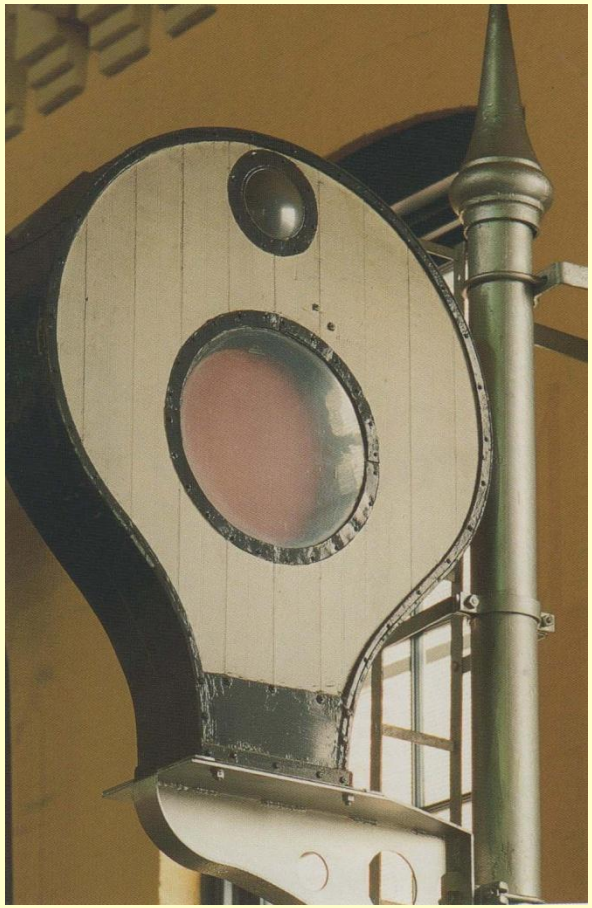
At about the same time a disk signal, popularly known as the "banjo signal" was developed to provide block occupancy indications



The disk was light weight and was moved easily compared to the heavy semaphore blade

The disk was electrically moved out of the window to display a "clear" signal and when de-energized would fall into being visible and indicate a "stop" signal

Signals



Since these were only 2-aspect signals they sometimes appeared in pairs where the "home" signal would have a red disk for "stop" and the distant signal would have a blue disk for "caution"

These were mostly used on Eastern railroads and by 1904 there were 4,697 "enclosed disc" signals working in automatic block service

The problem is these were difficult to see at night or in the fog

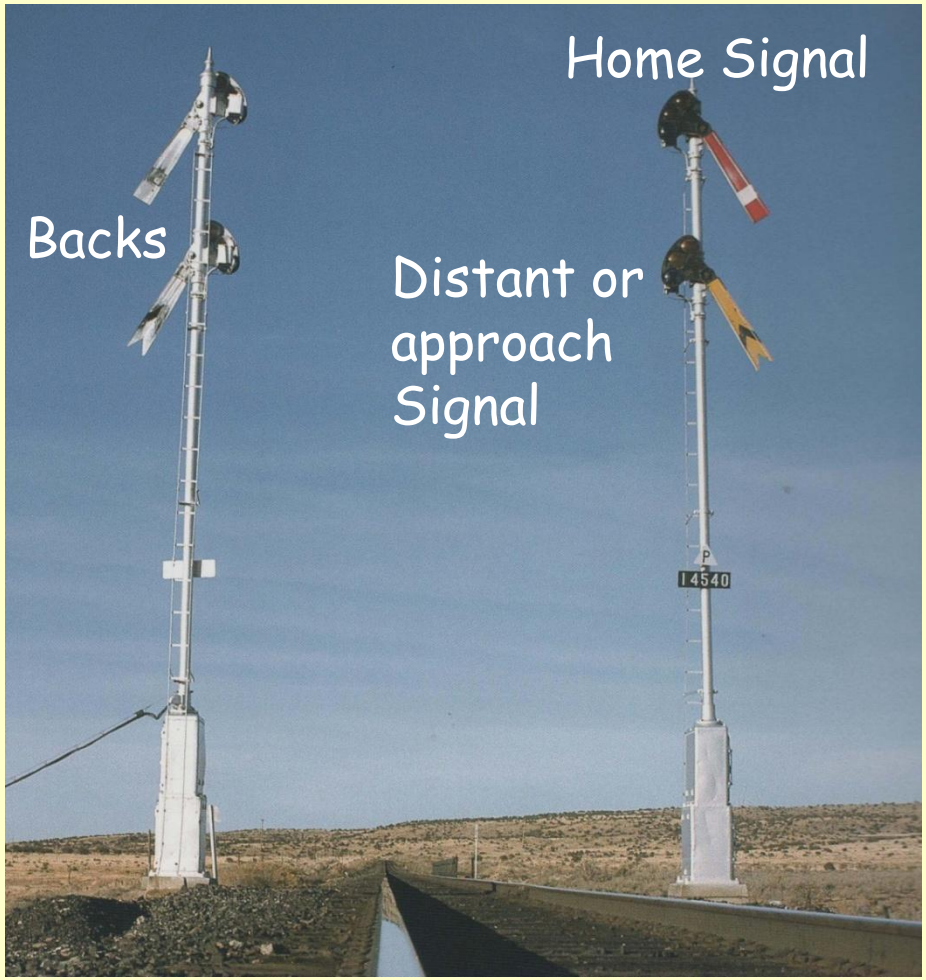
But then again, so were semaphores

Signals

In 1841 the London and Croydon Railway introduced the first "semaphore"

These were 2 position lower quadrant semaphores where the positions mimicked the hand signals given by the railroad police before fixed signals came along

The American Association of Railroads standard colors



Signals

The lower quadrant semaphores only displayed 2 aspects requiring 2 semaphores on a mast to display 3 aspects as seen in the previous slide

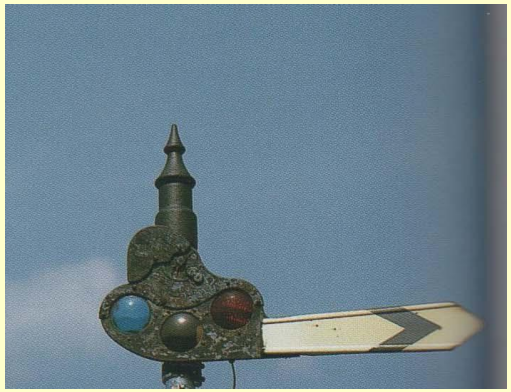
So the upper quadrant semaphore was invented and patented in 1903 which provided 3 aspects of information meaning only a single semaphore was required instead of 2 to convey the information

"Clear" "Approach" "Stop"

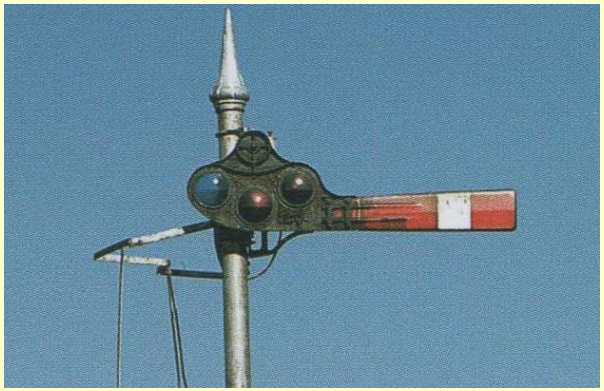
However, keeping with the failsafe requirement the horizontal now became the "Stop" and the vertical became the "Clear

Signals

Pop Quiz:
What difference is there between these two semaphores to the engineer?



The Yellow blade, an intermediate automatic block signal means
"Stop and Proceed"



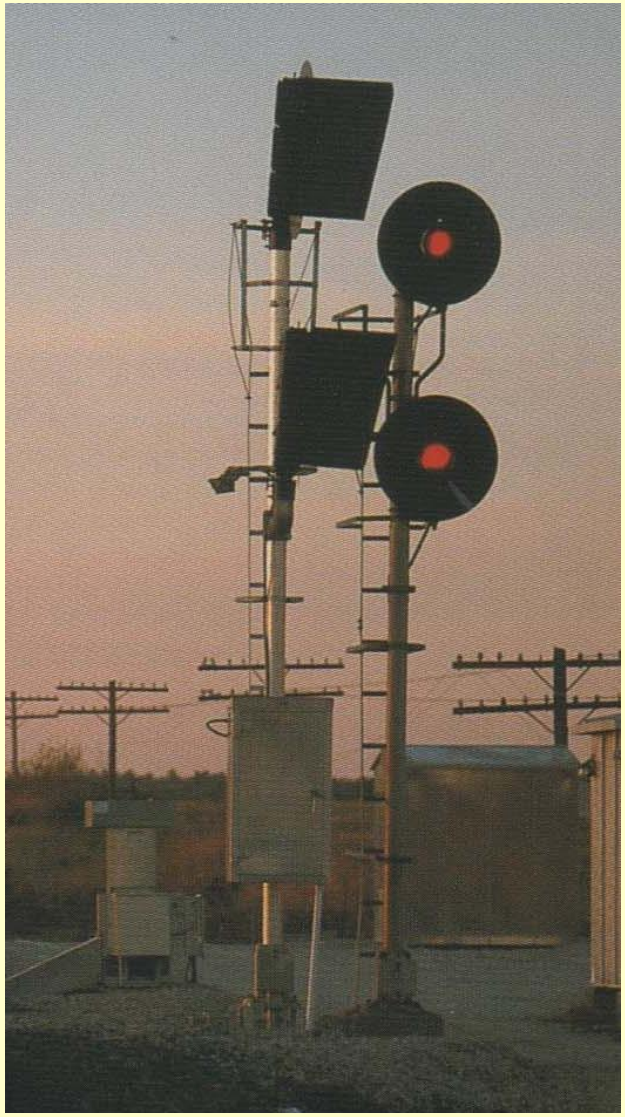
The Red blade, a home signal means
"Stop"

Signals

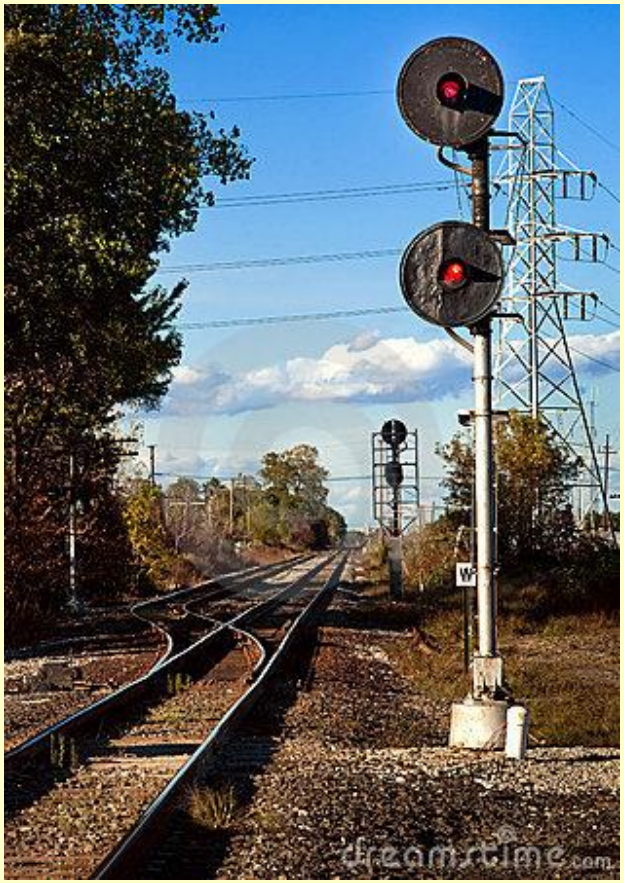
So colored lights were added where white, or clear, meant "clear" and red meant "stop"

However, this lead to a problem if a colored lens should break or fall out the indication would be interpreted as "clear" when a "stop" was meant

In the last quarter of the nineteenth century a "clear" aspect was changed to a green light on many railroads but not all



Signals



Then in 1894 the American Railway Association made the recommendations for standard aspects

These were green for "clear",
violet for "caution" and
red for "stop"

You can kind of see the handwriting on the wall, violet is close to red. Hmmm

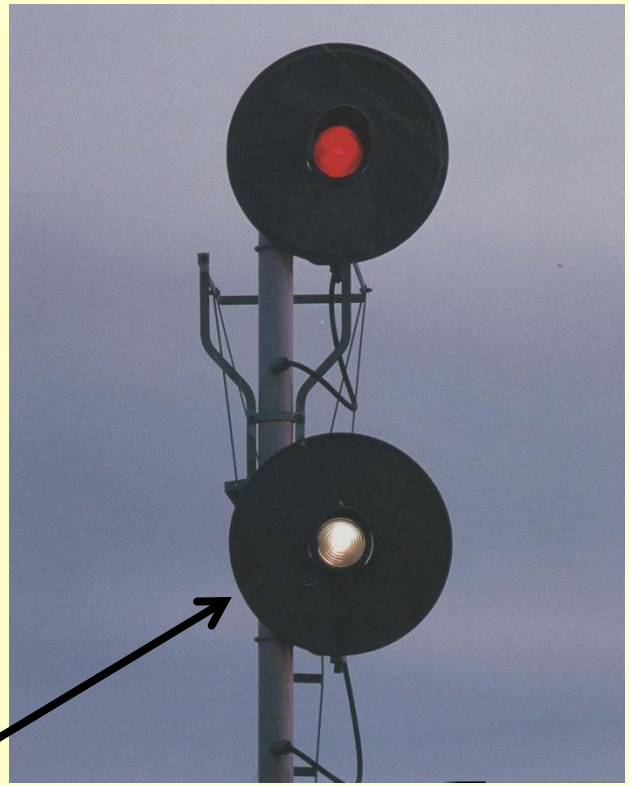
Signals

The New Haven Railroad in 1899 was the first to use the red, yellow, and green lights as used today

Between 1904 and 1908, Corning Glass set out to standardize not only the colors but the specific shades of glass and the way they were focused to make them easier to see

The results were

Red for "stop"
Yellow for "approach"
Green for "clear"
Lunar for "Restricting" (a moon like bluish white)



Signals

The "Searchlight" or "Target" type of signal uses a single focused lamp that is capable of displaying all 3 colors through a color filter

These could be seen up to 4,000 feet away.

These were widely used until the 1980's when they fell out of favor because they still had a moving part in them making them more likely to fail and other type of color-lights had advanced to make them worth the effort.

Signals

PRR has long been known as "I'll do it my own way" type of railroad, just look at their steam engines.

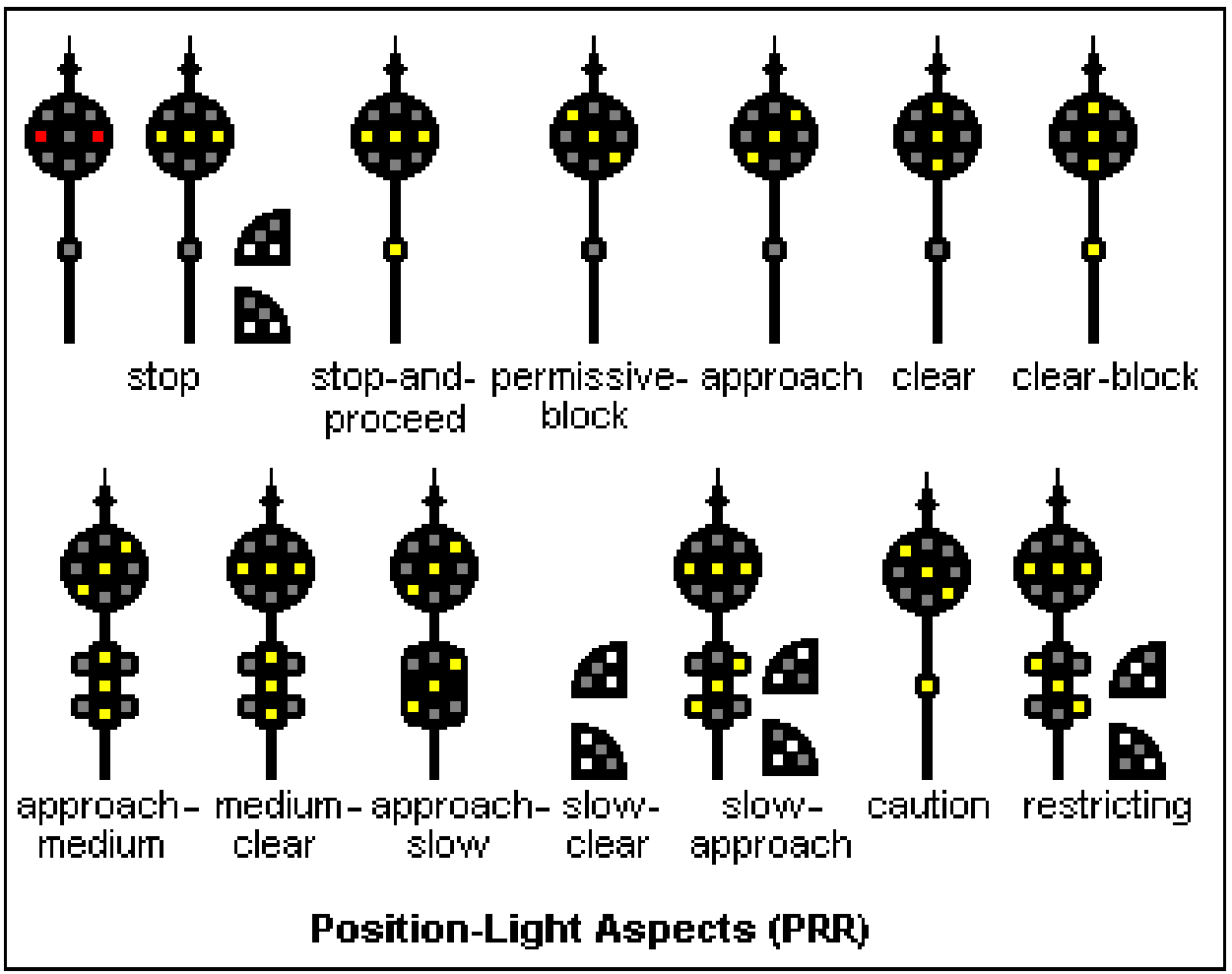
So they developed a light signal system that didn't rely on different colors but the arrangement of the lights on the target.

The idea was to use a series of 3 yellow lights, lunar for dwarfs, to mimic an upper-quadrant semaphore. To accommodate these lights the background had to be over 4 feet in diameter.

Vertical = clear
45 to the right = approach
45 to the left = restricting
Horizontal = stop

Signals

Here's the various Pennsy signal meanings



Signals

B&O decided to take the best of both worlds and developed the color-position-light system

Here the vertical "clear" lights are green

The horizontal "stop" lights are red

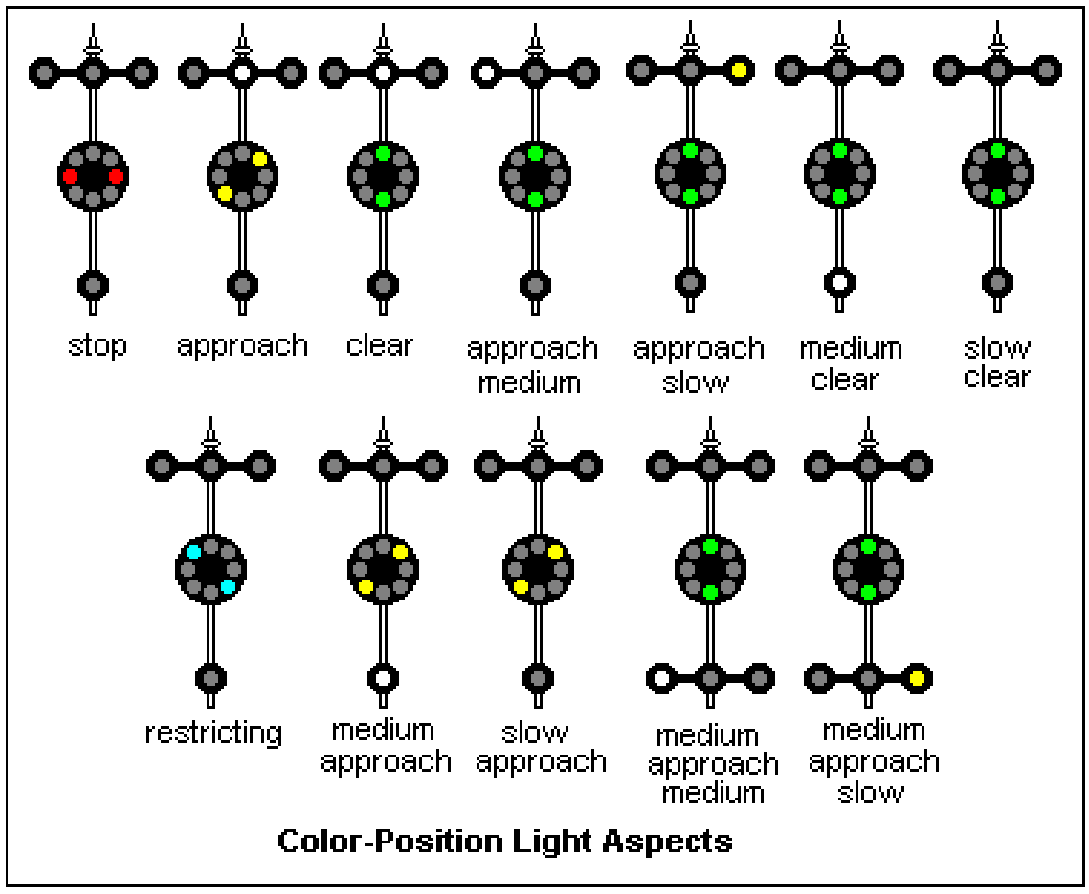
The forward slash "/" diagonal "approach" lights were yellow

The backward slash "\" diagonal "restricted" lights were lunar

They also used white and yellow lights at varying positions outside the target to indicate speed

Signals

B&O decided to take the best of both worlds and developed the color-position-light system



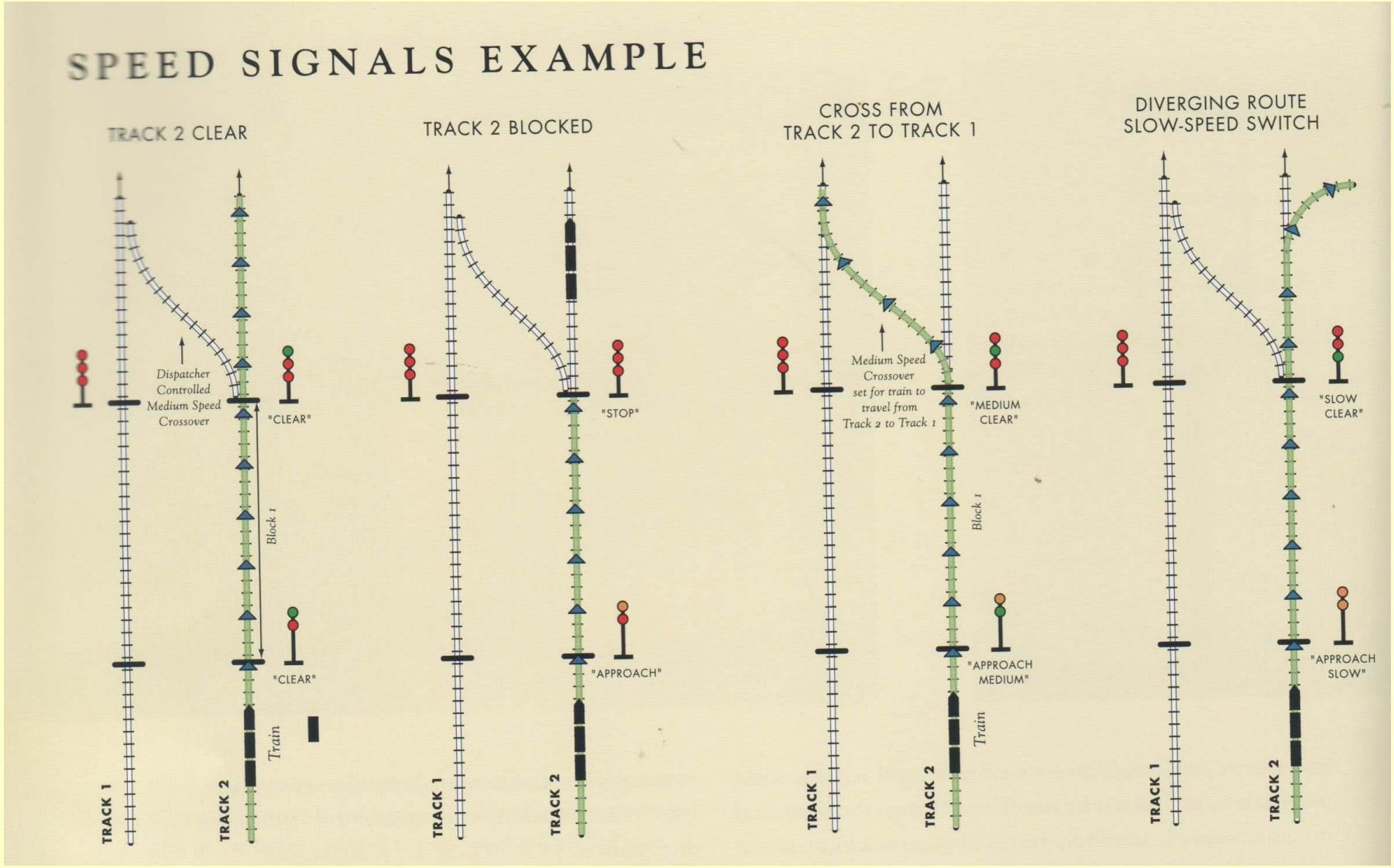
Signals

Speed Signaling

Uses a completely different set of rules and generally consists of 3 signal heads on a single mast. This could be a topic for another clinic all together. However, some terms need to be defined as they are used on route signaling as well

Normal speed (max mainline)
Limited speed – 45MPH
Medium speed – 30 mph
Slow speed – 15 to 20 mph
Restricted speed – 15 mph

Signals

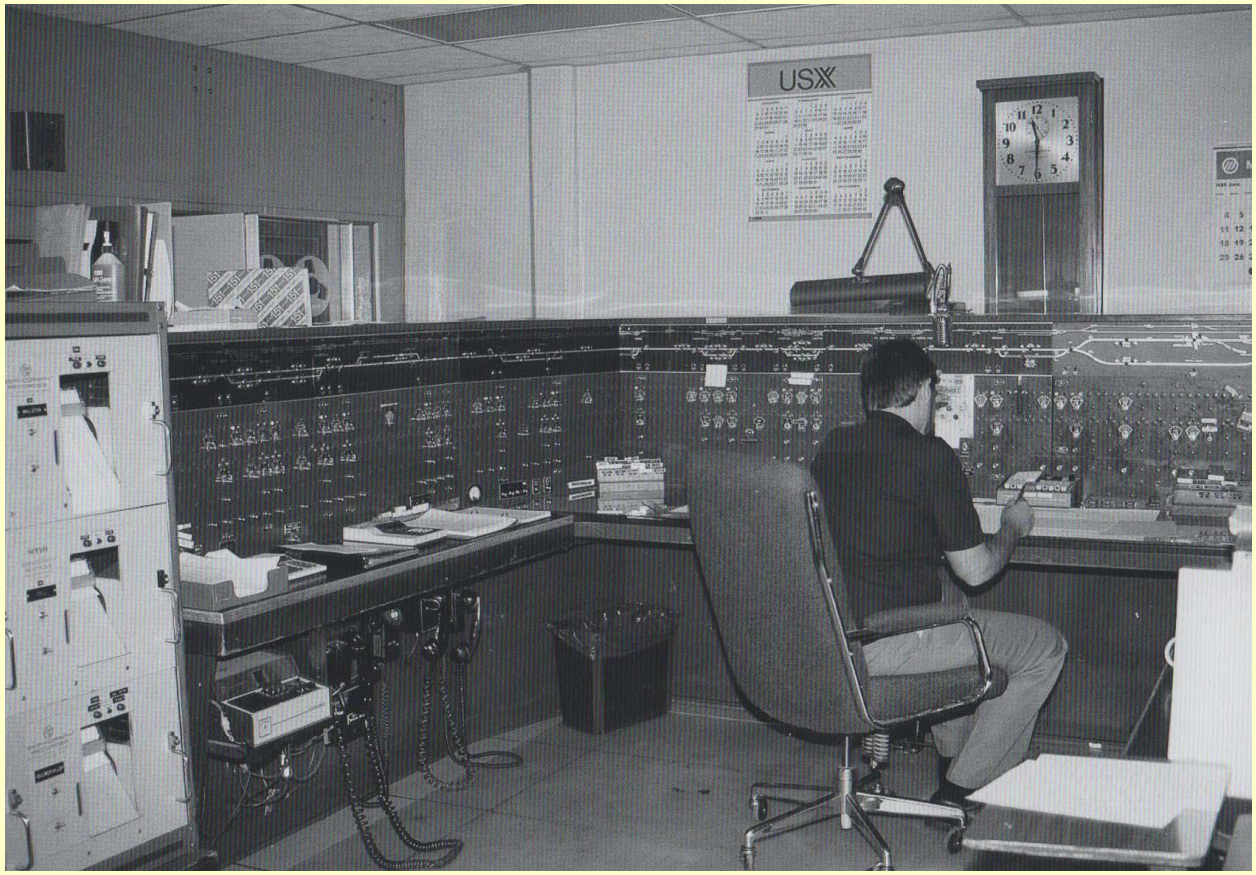

SPEED SIGNALS EXAMPLE
TRACK 2 CLEAR
Dispatcher Controlled Medium Speed Crossover
"CLEAR"
Block 1
"CLEAR"
Train
TRACK 1
TRACK 2
TRACK 2 BLOCKED
"STOP"
"APPROACH"
TRACK 1
TRACK 2
CROSS FROM TRACK 2 TO TRACK 1
Medium Speed Crossover set for train to travel from Track 2 to Track 1
"MEDIUM CLEAR"
Block 1
"APPROACH MEDIUM"
Train
TRACK 1
TRACK 2
DIVERGING ROUTE SLOW-SPEED SWITCH
"SLOW CLEAR"
"APPROACH SLOW"
TRACK 1
TRACK 2

Signals

Centralized Traffic Control (CTC)
As technology continued to improve it resulted in the consolidation of dispatching

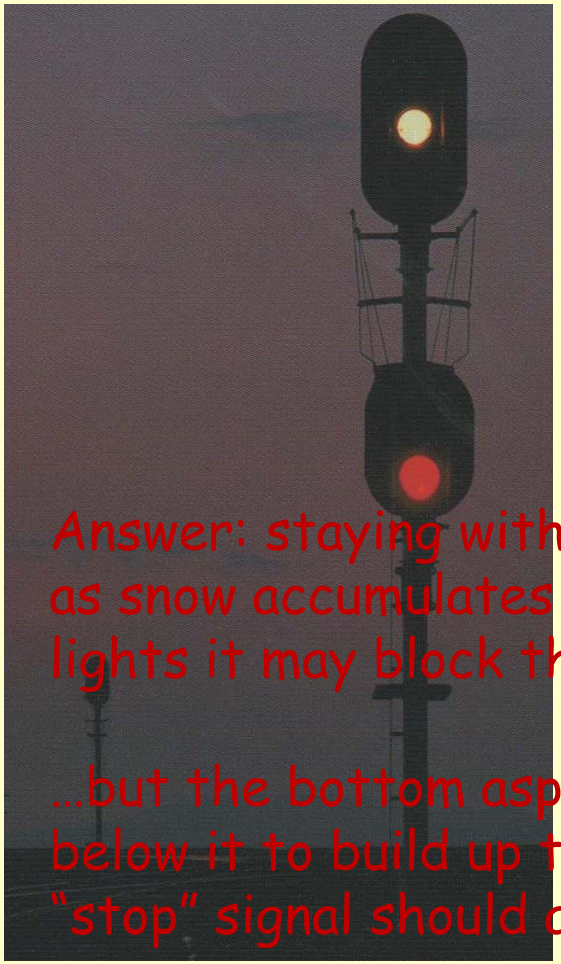
Now one dispatcher could control many miles of traffic

This combined with the mergers of many railroads precipitated the standardization of signaling



Signals

So this leads us to the modern color-light signals seen today



Pop Quiz: Why is the order of the lights reversed from standard automobile traffic lights?

Answer: staying with the failsafe mode as snow accumulates on the hoods of lights it may block the light above it…

…but the bottom aspect has nothing below it to build up the snow so the "stop" signal should always be visible

Signals

Signal Location

Bridges and cantilevers normally place signals over the tracks they govern

Typically a signal will be in front of the block it protects but things like location of stations, highway crossings, bridges, sharp curves, divergent track clearance must be taken into account

Signals

Signal Location

In some cases where there is double-trackage a single mast will hold 2 sets of signals and naturally the left set governs the left track and the right the right track

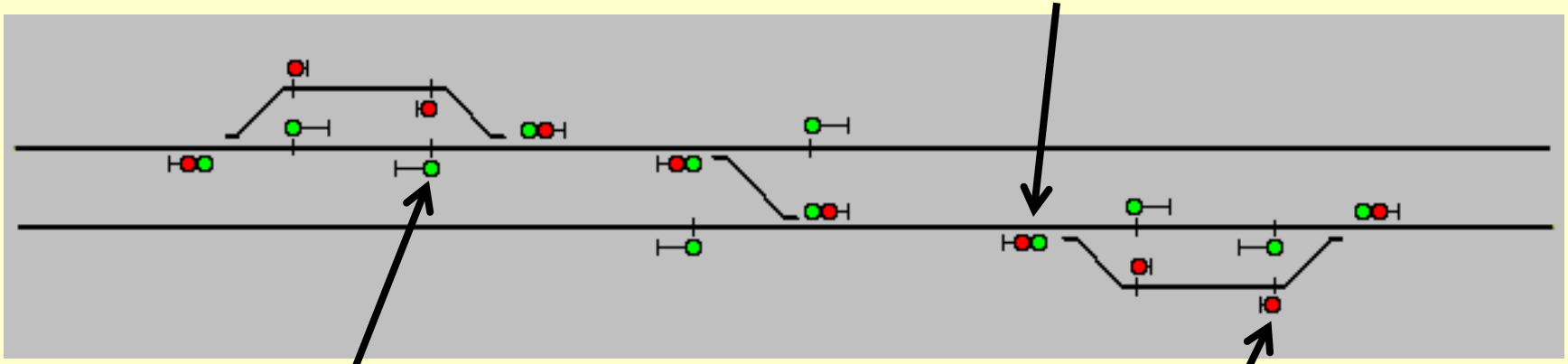
Pop Quiz – why are signals placed on the right side of the track if possible?

In the steam era the engineer was on right side of cab with limited forward visibility

Signals

Here's an example of signal placement on a
double track mainline with passing sidings and a cross over

Top signal for mainline and bottom for siding

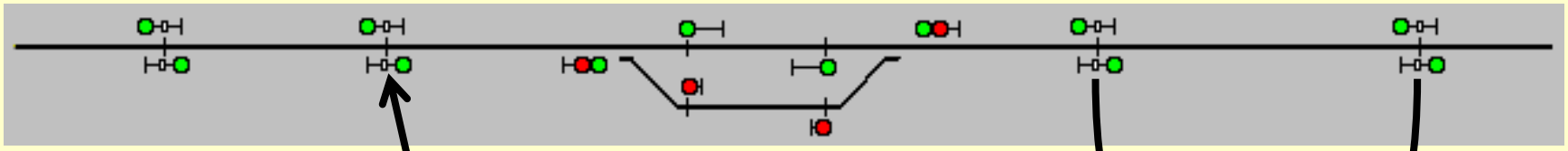


Mainline frog signals are full mast

Divergent frog signals are Dwarf

Signals

So, let's look at what happens as a train travels along this route



Intermediate Block signals are indicated with a number board

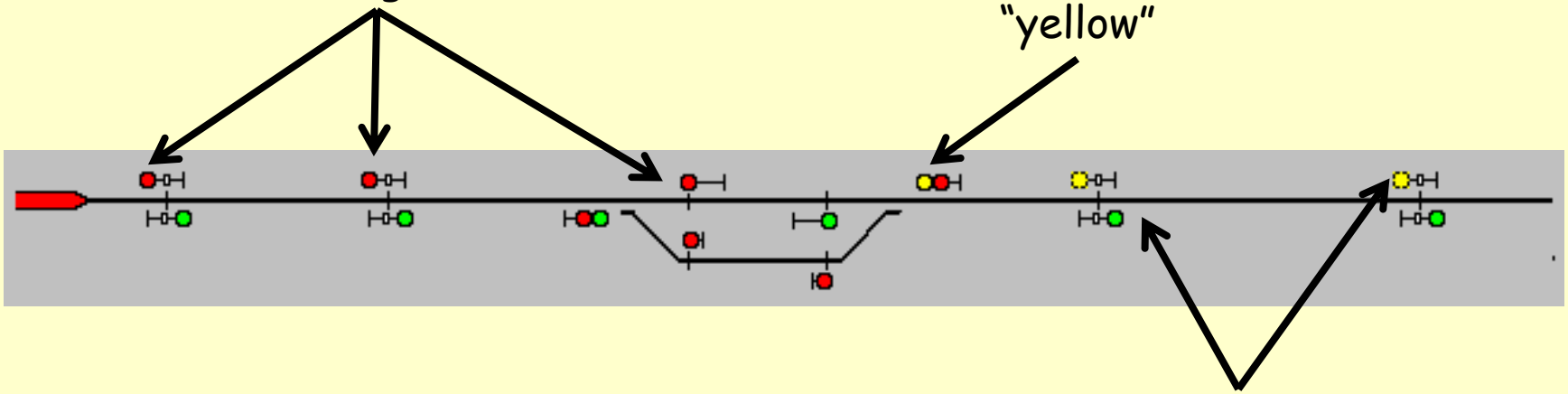
Block lengths are determined by lengths of trains and stopping distances

Signals

A Eastbound train enters an intermediate block

All blocks on the single mainline go "red"

A subsequent block where a passing can take place goes "yellow"



Any blocks on a single mainline before the yellow go "Flashing Yellow"

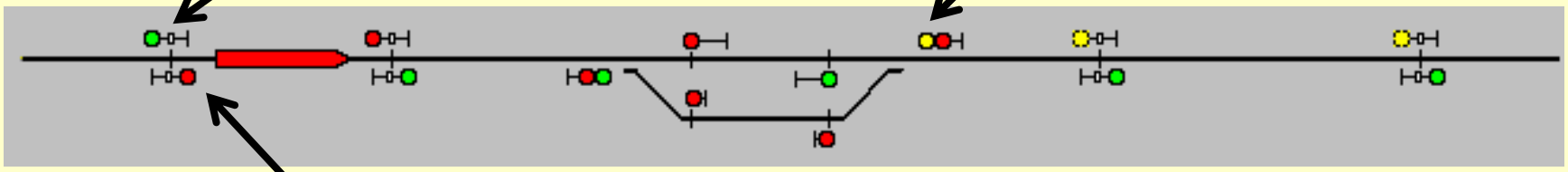
Green = "Clear"
Yellow = "Approach"
Flashing Yellow = "Approach Medium"
Red = "Stop"

Signals

The Eastbound train progresses to the next intermediate block

Signals behind the train return to "Green"

This stays "yellow" since there is a passing siding

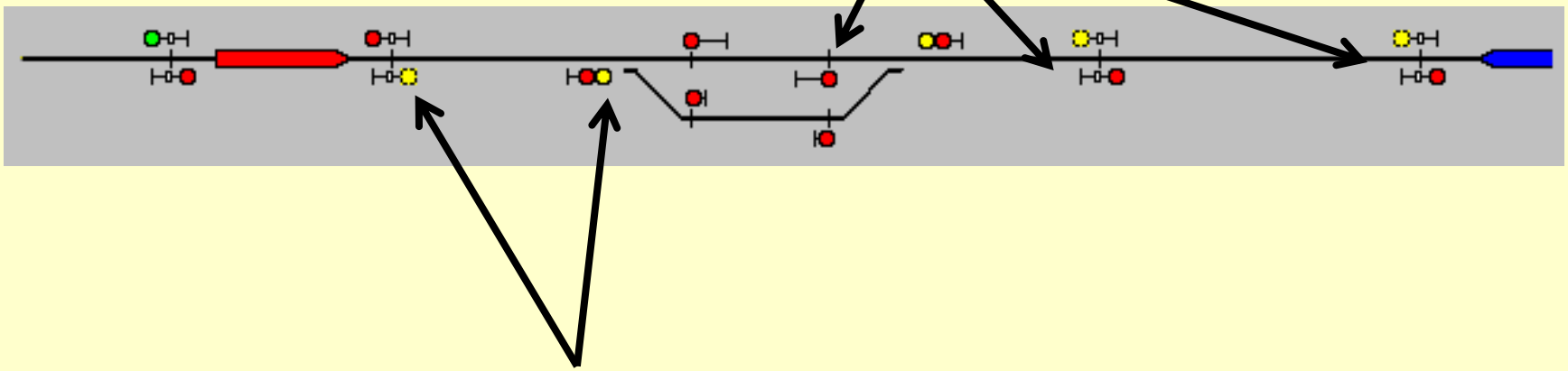


The following signal goes "RED" protecting the rear of the train

Signals

Oh No! A Westbound train enters the territory!

This throws all Eastbound signals between the Westbound train and the passing siding to "RED"

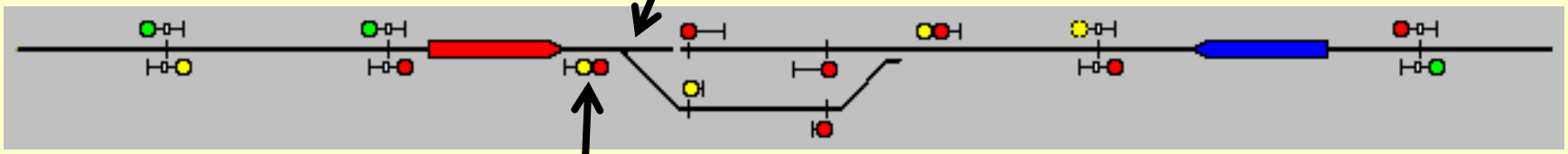


And causes the preceding block to go "Yellow" and the one before it to go "Flashing Yellow"

Signals

No problem, the Dispatcher sees it and throws the west turnout sending the Eastbound into the siding

The Westbound keeps coming …. was the dispatcher in time?

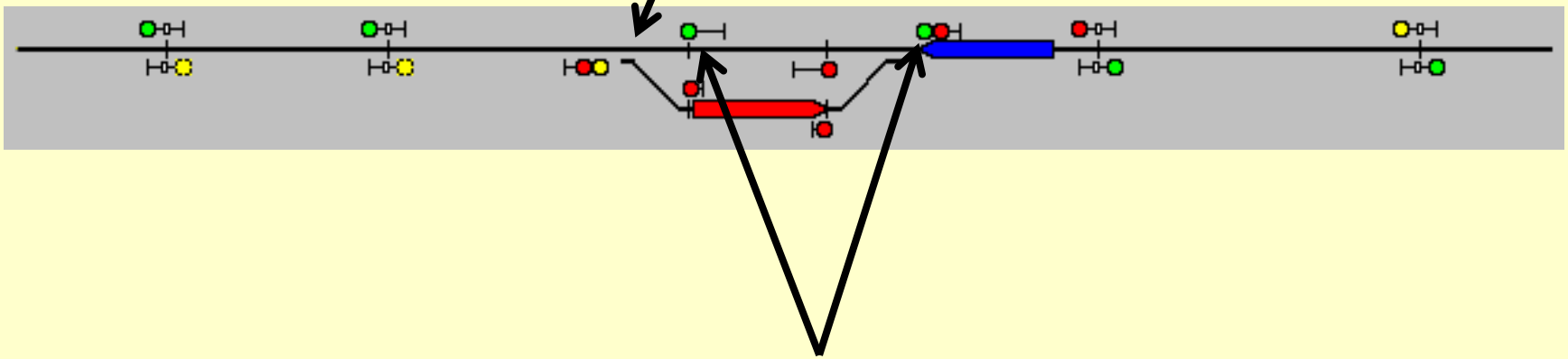


This changes the aspects on the double signal in front of the turnout indicating that he is to take the turnout at reduced speed

Signals

The Eastbound takes the siding and the Dispatcher re-aligns the turnout for the main

The Westbound continues on while the Eastbound waits in the siding

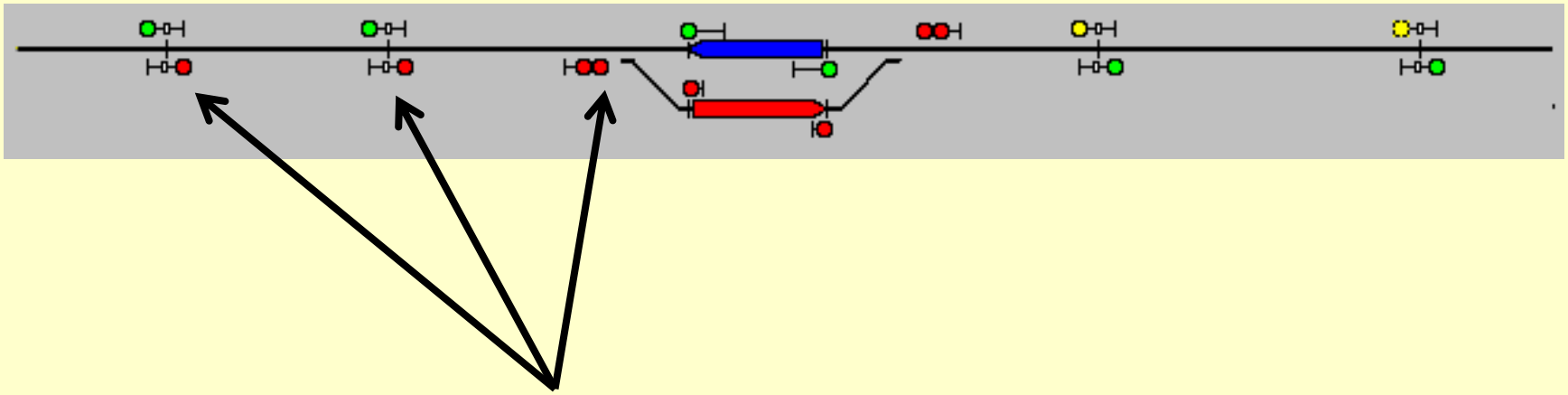


This causes the signals for the Westbound to return to "Green"

Signals

The "Meet" takes place without a hitch

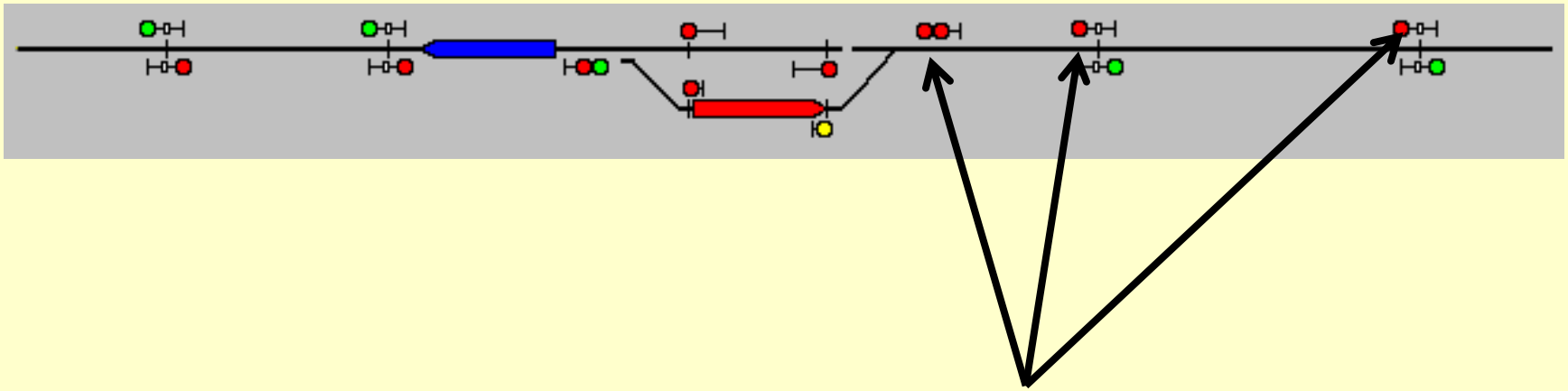
Notice the "Following" signals



Since there's no other place to pass all eastbound signals prior to the siding drop to "RED"

Signals

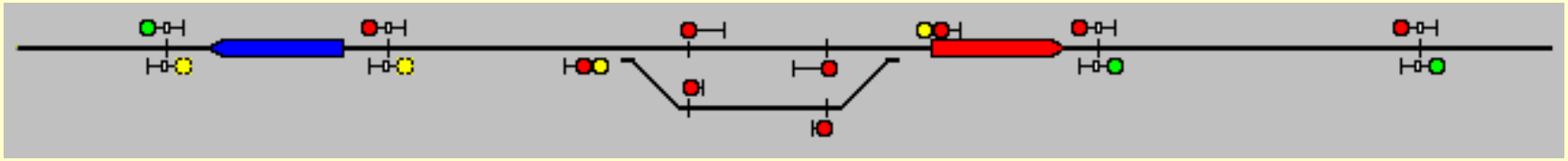
The Westbound has now cleared the siding so the Dispatcher can set the East switch to "Reverse" clearing the Eastbound train on its way



With the switch thrown and the siding occupied the westbound signals drop to "Red" to protect the head of the Eastbound train

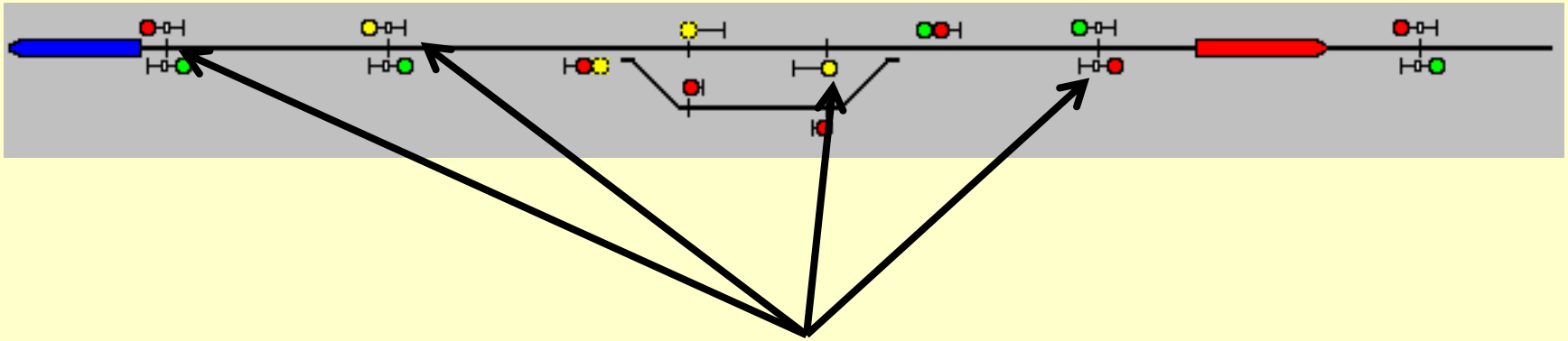
Signals

After the Eastbound re-enters the mainline the Dispatcher re-aligns the East switch to "Normal" and the trains are continuing on their way



Signals

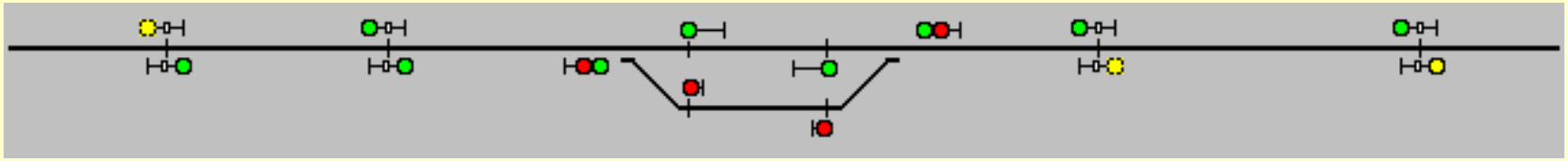
Signals start returning to normal as the trains separate



Again, notice the "Following" signals as the trains progress

Signals

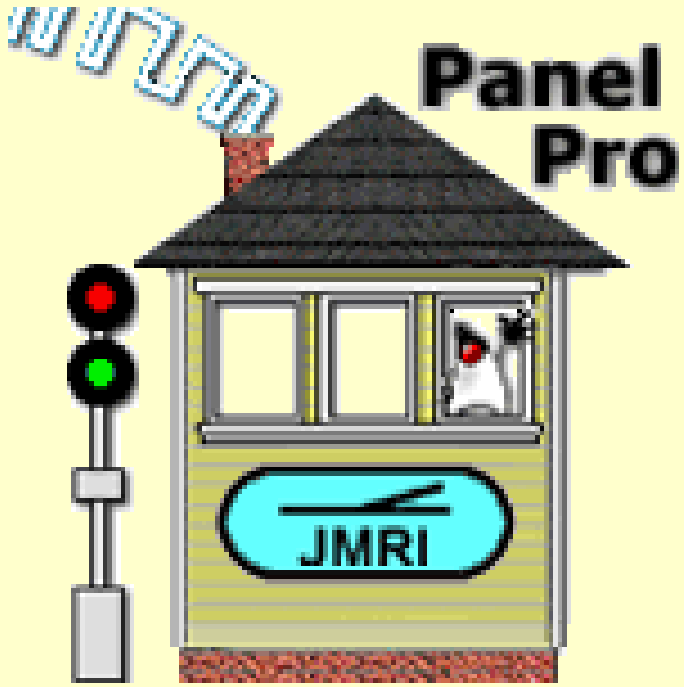
…..and everyone lives happily ever after



Signals

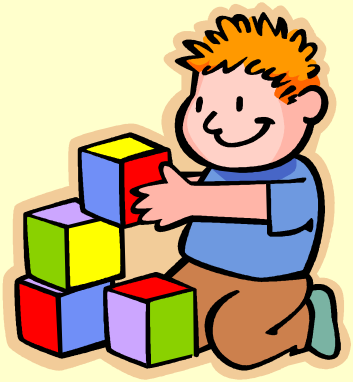
Questions?

Signals



Next month we'll show you how to set up JMRI to make all that signal magic work!

Signals



Then in Sept we're going to build some signals!